Technical Notes

1. The standard system of fixed plastic film capacitor for use in electronic equipment

The standard system of fixed plastic film capacitor for use in electronic equipment includes the foundational standard, generic specification, sectional specification, blank detail specification and detail specification, or manufacturer specification.

Generic specification specifies the terminology, inspection procedures and test methods applied in sectional and detail specifications. Sectional specification is classified according to the specific dielectric material and construction of capacitor,

1、电于设备用固定薄膜电容器标准体系

电子设备用固定电容器的标准体系是由基础标准，总规范，分规范，空白详细规范，以及详细规范（即企业标准）组成。

总规范规定了分规范和详细规范中使用的标准术语、检验程序和试验方法。分规范是按电容器的介质和结构分类的，它是对该电容器规定优先额定值和特性，并从总规范中选择适当的质量评定程序、试验和测量方法，以及给出一般

标准号(No.)	标准(Standards)
GB/T 2693 (IEC 60384-1)	电子设备用固定电容器第 1 部分：总规范 Fixed capacitors for use in electronic equipment Part 1:Generlc specification
GB/T 10190 (IEC 60384-16)	电子设备用固定电容器第 16 部分：分规范：金属化聚丙烯膜介质直流固定电容器 Fixed capacitors for use in electronic equipment Part 16: Sectional specification: Fixed metalized polypropylene film dielectric D.C. capacitor
GB/T 10191 (IEC 60384-16-1)	电子设备用固定电容器第 16 部分：空白详细规范：金属化聚丙烯膜介质直流固定电容器评定水平 Fixed capacitors for use in electronic equipment Part 16: Blank detail specification: Fixed metalized polypropylene film dielectric D.C. capacitor Assessment level E
GB/T 17702 (IEC 61071)	电力电子电容器 Power electronic capacitors
GB/T 14472 (IEC 60384-14)	电子设备用固定电容器第 14 部分：分规范：抑制电源电磁干扰用固定电容器 Fixed capacitors for use in electronic equipment Part 14: Sectional specification: Fixed capacitor for

2. General Description of Film Capacitors

2-1 Principle of Capacitor Construction

The principle construction of a parallel plate capacitor is shown in Fig.1. When a voltage V is applied between the conducting ele[...] to each other, a certain amount Q of electric charge pro[...]can be stored on the surfaces of the dielectric. The pro[...]ed capacitance C, designating the ability of capacit[...]electric field.

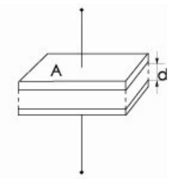


Fig. 1

Q=C.V

Q: Charge(C)

V: Voltage (V)

C: Capacitance (F)

The capacitance C of capacitor can be expressed by the following equation: $C= \varepsilon_0 \cdot \varepsilon \cdot A/d$

ε: dielectric constant

ε_0: dielectric constant in vacuum (= 8.85×10^{-12} F/m)

A: electrode area [m^2]

d: electrode distance [m]

The dielectric constant of Polypropylene film is 2.2. Larger capacitances can be obtained by enlarging the electrode area A or by reducing the distanced.

Table 1 shows the dielectric constants of typical film dielectrics used in

2. 薄膜电容器的基本概要

2-1. 电容器的结构原理

平行板电容器的基本结构原理可以用图 1-1 来描述。当一个电压 V 施加在彼此正对的两块导[...]电压成正比的电荷量 Q 将被储存在电介质[...]示称电容器在电场中储能能力的比例常数[...]

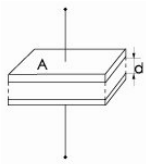


图 1

Q=CV

Q：电量（C）

V：电压（V）

C：电容量（F）

电容器的容量可以用以下公式来表示：

$C= \varepsilon_0 \cdot \varepsilon / d$

ε：电介常数

ε_0：真空中的电介常数（=8.85×10^{-12}F/m）

A：极板面积[m^2]

d：极板距离[m]

聚丙烯膜的相对介电常数为 2.2。要想获得更大的电容，可以通过增加表面积 A 或者减少其厚度 d 来获得。

表 1-1 列出了电容器中常用的典型介质的相对介电常数，在很多情况下，电容器的命名通常是与介质所使用的材

3. Basic parameters and terms

3-1. Rated capacitance C_R

Nominal value of the capacitance at 20℃ and measuring frequency range of 50 to 120 Hz.

3-2. Rated voltage U_R

Maximum operating peak voltage of either polarity but of a non reversing type wave form,for which the capacitor has been designed, for continuous operation.

3-3. Rms voltage U_{rms}

Root mean square of max. Permissible value of sinusoidal a.c. voltage in continuous operation.

3-4. Ripple voltage U_r

Peak- to- peak alternating component of the unidirectional voltage. The maximum allowed rms ripple voltage has to be lower than 10% of the rated voltage.

3-5. Non-recurrent surge voltage U_s

Peak voltage induced by a switching or any other disturbance of the system which is allowed for a limited number of times and for durations shorter than the basic period.

- Maximum duration: 50 ms/pulse
- Maximum number of occurrences: 1000 (during load)

3-6. Insulation voltage U_i

Rms value of a.c. voltage designed for the insulation between terminals of the capacitor to case or earth. The insulation voltage is equal to the rated voltage of the capacitor, divided by$\sqrt{2}$. unless otherwise specified.

3- **3-14. Loss factor of the capacitor tgδ**

The dissipation factor is ratio between reactive power of the impedance

3- of the capacitor and effective power when capacitor is submitted to a sinusoidal voltage of specified frequency; it is that ratio between 1he

3- equivalent series resistance and the capacitive reactance of o capacitor.

3-15. Dielectric power loss P_d

op Loss power induced by dielectric polarization or dielectric conductance. The value is following:

3- $P_d=\hat{U}^2 x \pi x f_o x C x_0$

Where, for DC capacitors: $\hat{U}=\sqrt{2}U_R/10$

sy For AC capacitors: $\hat{U}=\sqrt{2}U_{rms}$

du For GTO snubber capacitors: $\hat{U}=\sqrt{2}U_{RDC}/2$

3- f_0: fundamental frequency

C: capacitance

op **3-16. Joule power loss P_j**

Loss power induced by series resistance of the capacitor under rms

3- current. The value is following: $P_j=I^2_{rms} x R_s$

3-17. Capacitor losses P_t

ca Active power dissipated in the capacitor, consists of dielectric loss and

3- joule loss.,i.e.$P_t=P_d+P_j$

3-18. Maximum power loss P_{max}

ra Maximum power loss at which the capacitor may be operated at the maximum case temperature.

3-19. Self-inductance L_s

Represents the sum of all inductive elements which are for mechanical

3、基本参数和术语

3-1、额定容量 C_R

标称电容值在 20℃和 50∽12Hz 频率下测定。

3-2、额定电压 U_R

设计电容器时所采用的非反复型波形的任一极性的可连续运行的最高运行峰值电压。基值应大于直流工作电压与纹波电压峰值之和。

3-3、有效值电压 U_{rms}

电容器在连续运行过程中允许出现的最大正弦交流电压的均方根值.

3-4、纹波电压 U_r

单向电压的峰到峰的交流分量。

纹波电压的方均根值应低于额定电压的 10％。

3-5、非周期冲击电压 U_s

由切换或系统中任何别的扰动所导致的峰值电压，此电压只允许出现有限的次数，且每次持读时问应比基本周期短.

-最大持续时间：50 毫秒/脉冲

-最大出现次数：1000（负载）

3-6、绝缘电压 U_i

设计电容器时规定的电容器端子对外壳或对地交流电压的均方根值。若未作说明，此绝缘电压等子额定电压除以$\sqrt{2}$.

3-14、电容器的损耗因素 tgδ

在规定频率的正弦波电压作用下，电容器的损耗功率除以电容器的无功功率。其值为等效串联电阻和容抗之比。

3-15、介质损耗功率 P_d

电容器的电介质由于极化或电导引起的损耗，其值为：

$P_d=\hat{U}^2 x \pi x f_o x C x tg\delta_0$

直流电容器：$\hat{U}=\sqrt{2}U_R/10$

交流电容器：：$\hat{U}=\sqrt{2}U_{rms}$

GTO 吸收电容器：$\hat{U}=\sqrt{2}U_{RDC}/2$

f_0：施加在电容器上电压的基本频率

C：电容量

3-16、焦耳损耗功率 P_j

当电容器通过有效电流时，由于串联电阻 R_s 发热而引起的损耗，其值为: $P_j=I^2_{rms} x R_s$

3-17、电容器的损耗功率 P_t

电容器所消耗的有功功率，由介质损耗与焦耳损耗组成，即 $P_t=P_d+P_j$

3-18、最大损耗功率 P_{max}

在最高运行温度下电容器可以承载的最大损耗功率。

3-19、自感 L_s

电容器由于自身结构或组成的原因所表现出来的电感

3-26. Temperature coefficient of capacitance a

The change rate of capacitance with temperature measured over a specified range of temperature. It is expressed in parts per million per Celsius degree 10^{-6}/℃)and referred to 20℃,(10^{-6}/℃=1ppm/℃)

C: Capacitance at temperature T_i

C_0: Capacitance at temperature T_o (20±2)℃

$a_i=C_i x C_0/C_0|T_i-T_0)$

3-27. Voltage between terminals U_{π}

Voltage between terminals (at 20℃,10s): 1.5x U_{RDC}

3-28. Voltage between terminals and case U_{TC}

Voltage between terminas and case (at 20℃,10s):

2 x U_i+1000 or 3000 (V_{AC}) whichever larger

3-29. Climatic category

The climatic category which the capacitor belongs to is expressed in three numbers separated by slashes, (IEC 60068-1: example 55/85/56)

55 / 85 / 56

days relevant to the damp heat test (56days)

the upper category temperature (+85°C)

the lower category temperature (-55°C)

3-30. Insulation resistance (IR)/time constant (t)

The insulation resistance is the ratio between an applied D.C.voltage and the resulting leakage current after a minute of charge. It is expressed in MO. The time constant is expressed in seconds with the following formula:

t[s]=IR[MΩ]×C[μF]

3-31. Self-healing (only for metalized film capacitor)

The metal coatings of the metalized film, which are vacuum-deposited directly onto the plastic film, have a thickness of only several tens nm. At weak points or impurities in the dielectric, a dielectric breakdowen would occur. The energy released by the arc discharge in the breakdown channel is sufficient to totally evaporate the thin metal coating in the vicinity of the channel. The insulated region thus resulting around the former faulty area will cause the capacitor to regain its full operation ability.

3-26、容量温度系数 a

电容器在规定的温度内容量随温度的变化率。以 20℃时电容量为参数，用百万分之一每摄氏度（10^{-6}/℃）表示。(10^{-6}/℃=1ppm/℃)

C：电容器在温度 T_i 时容量

0_0：电容器在 T_o (20±2)℃时的容量

$a_i=C_i x C_0/C_0|T_i-T_0)$

3-27、端子与端子间耐压U_{π}

电容器端子与端子间耐压（20℃,10s): 1.5x U_{RDC}

3-28、端子与外壳间耐压 U_{TC}

电容器端子与外壳间耐压（20℃,10s）：

2×U_i+1000 or 3000 (V_{AC})取大者

3-29、气候类别

电容器所属的气候类别用斜线分隔的二个数来表示（IEC 60068-1：如：55/85/56）

55 / 85 / 56

稳态湿热实验的天数（56 天）

上限类别温度（+85℃）

下限类别温度（-55℃）

3-30、绝缘电阻(IR)时间常（t）

绝缘电阻为电容器充电一分钟后所加的直流电压和流经电容器的漏电流值的比值，单位为 MΩ。时间常数为绝缘电阻和电容量的乘积，通常以秒表示,公式如下：

t[s]=IR[MΩ]×C[μF]

3-31、自愈性（仅对金属化膜电容器）

金属化膜的金属镀层是通过真空蒸发的方法将金属沉积在薄膜上，厚度只有几十个纳米，当介质上存在弱占、杂质时，可能发生局部电击穿，电击穿处的电弧放电所产生的能量足以使电击穿点附近的金属镀层蒸发，使击穿点与周围极板隔开，电容器电气性能即可恢复正常。

4. Expected lifetime of the capacitor

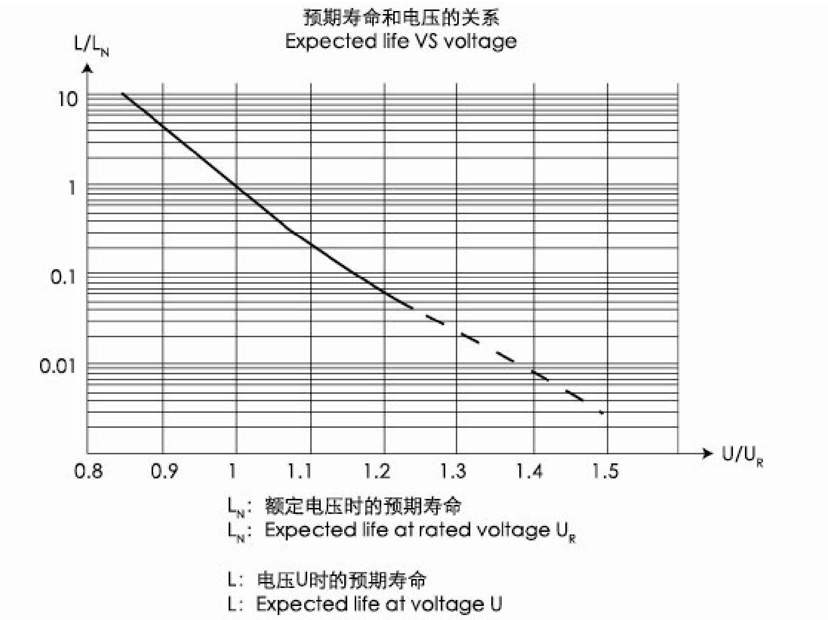
The expected lifetime of the capacitor depends on the applied voltage and the hot spot temperature during operation. For capacitors applied in different situation, the designed average service lifes are different, me capacitors used In DC-Link circuits win have a expected lifetime of probable 100000 hrs at rated voltage and 70^ hot spot temperature.

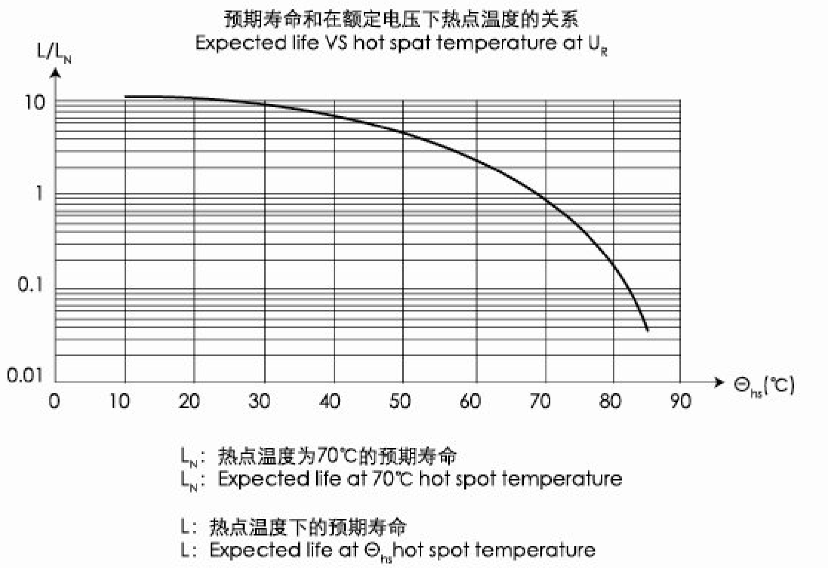
Expected lifetime is a statistical value calculated on the basis of experience and on the oretical evaluations. The following diagrams show the correlation between expected life, operating voltage and hoi spot temperature. The diagrams should be considered only as a theoretical reference. Please consult our technical department in case of working condition different from the rated ones.

4、电容器的预期寿命

薄膜电容器的预期寿命与电容器的工作电压及热点温度有关。对于不同的应用场合，电容器的设计寿命不同。应用在直流滤波电路中电容器，在额定电压及热点温度为 70℃的应用条件下，预期寿命可达到 100000 小时。

电容器的预期寿命是一个基于实线经验和理论计算的统计学数值。以下图片是电容器的预期寿命与运行电压及热点温度之间的特性曲线，仅仅作为理论参考。对于工作条件与额定条件有差别的情况，可以联系我们的技术部门。

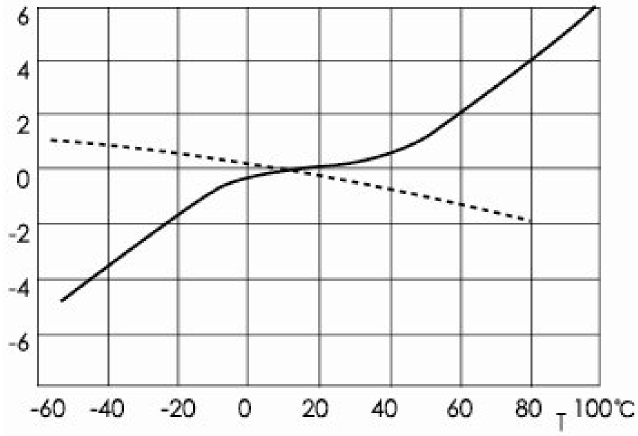




5. Electrical behaviour

5. 电气特性

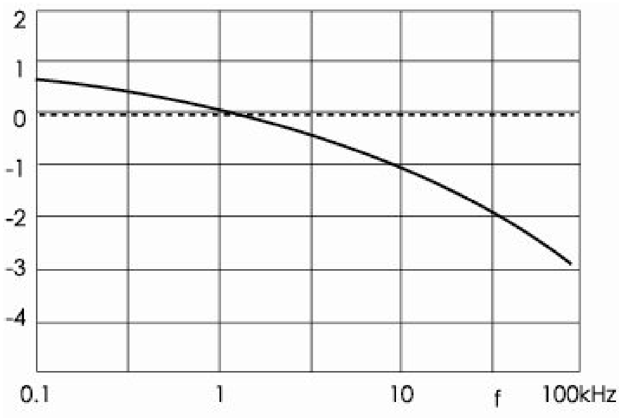
△C/C(%)



1kHz 时容量与温度的关系

Capacitance vs. temperature at 1 kHz

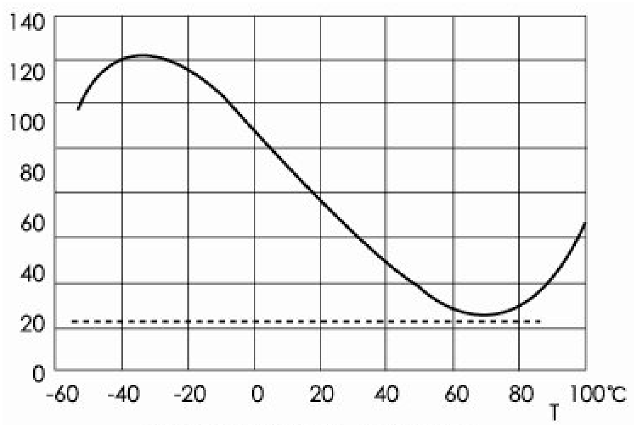
△C/C(%)



容量与频率的关系（常温状态下）

Capacitance vs. frequency (Room temperature)

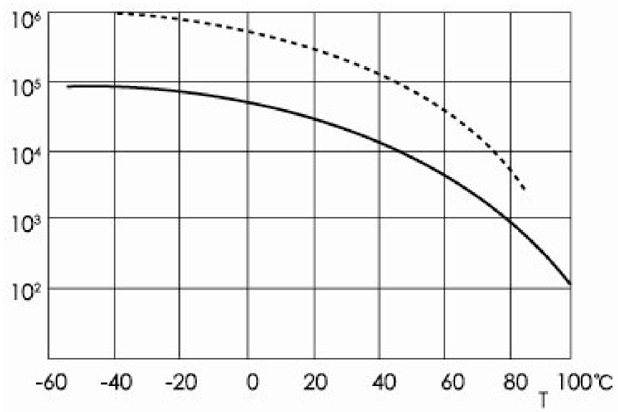
tgδ (x 10^{-4})



1kHz 时介质损耗角与温度的关系

Dissipation facor vs. temperature at 1 kHz

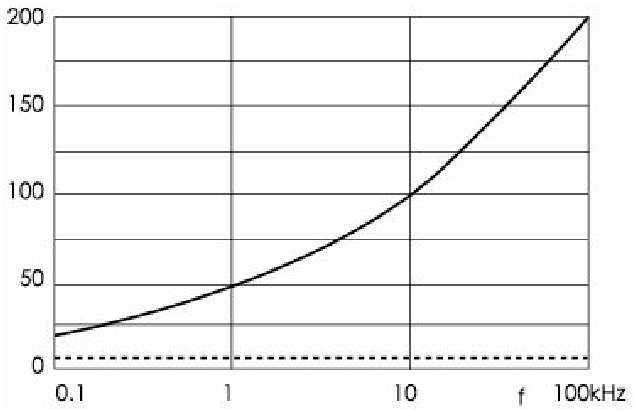
IR(MΩ)



IR 与温度之间的关系

IR vs. temperature

tgδ (x 10^{-4})



介质损耗角与频率的关系（常温状态下）

Dissipation facor vs. frequency (Room temperature)

----- 聚丙烯薄膜（Polypropylene Film）

—— 聚酯薄膜（Polyester Film）

6. Application guidelines

6-1. Operation voltage

The plastic film capacitor varies in the maximum applicable voltage depending on the applied voltage waveform, current waveform, frequency, ambient temperature (capacitor surface temperature), capacitance value, etc. Be sure to use capacitors within the specified values by checking the voltage waveform, current waveform, and frequency applied to them (in the application of high frequency, the permissible voltage vanes with the type of the capacitor. For detail see the specification).

6-2. Operating current

The pulse (or AC) current flowing through the capacitor is expressed as: I=C× dV/dt.

Due to the fact that dissipation factor of the capacitor will generate the internal heat under the application of high frequency or high pulse current, temperature rise in it will occur and may cause deterioration of withstanding voltage, even lead to break down (smoking or firing). Therefore, the safety use of capacitor must be within the rated voltage (or category voltage) and the permissible current.

The rated current must be considered by dividing into pulse current (peak current) and continuous current (rms current) depending on the break down mode, and when using, should make sure the both currents are within the permissible values.

6-3. Calculation of rms In various waveforms

In each waveform, calculate the rms value In the following formula.

6、应用指南

6-1、工作电压

薄膜电容器的选用取决于施加的最高电压，并爱施加的电压波形、电流波形、频率、环境温度（电容器表面温度）、电容量等因素的影响。使用前请先检查电容器两端的电压波形、电流波形和频率（在高频场合，允许电压随着电容器类型的不同而改变，详细资料请参阅说明书）是否在额定值内。

6-2、工作电流

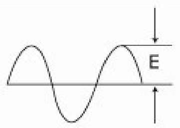
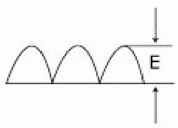
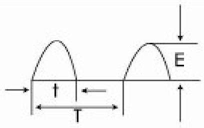
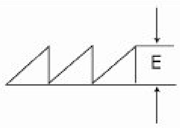
通过电容器的脉冲（或交流）电流等于电容量 C 与电压上升速率的乘积，即 I=C×dV/dt.

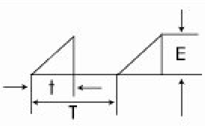
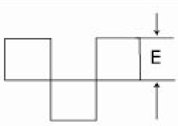
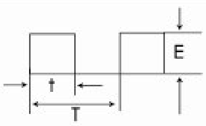
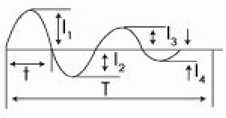
由于电容器存在损耗，在高频或高脉冲条件下使用时，通过电容器的脉冲（或交流）电流会使电容器自身发热而有温升，将会有热击穿（冒烟、起火）的危险。因此，电容器安全使用条件不仅受额定电压（或类别电压）的限制，而且受额定电流的限制。

额定电流被认为是由击穿模式决定的脉冲电流（峰值电流，即由 dV/dt 指标所限制的）和连续电流（以峰峰值或有效值表示）组成，当使用时，需确认这两个电流都在允许范围之内。

6-3、各种波形的有效值换算关系

不同的波形有效值按下面的公式计算。

种类(type)	1	2	3	4
波形 (waveform)				
有效值(rms)	$E/\sqrt{2}$	$E/\sqrt{2}$	$E\sqrt{t/(2T)}$	$E/\sqrt{3}$

种类(type)	5	6	7	8
波形 (waveform)				
有效值(rms)	$E\sqrt{t/(3T)}$	E	$E\sqrt{t/T}$	$\sqrt{\frac{t}{2T}(I_1^2+I_2^2+I_3^2+I_4^2)}$

6-4. Charging and discharging

Because the charging and discharging current of capacitor is obtained by the product of voltage rise rate (dV/dt) and capacitance, low voltage charging and discharging may also cause deterioration of capacitor such as shorting and open due to sudden charging and discharging current. When charging and discharging, pass though a resistance of 20Ω/V to 1000Ω/V or more to limit current.

When connecting multiple film capacitors in parallel in withstand voltage lest or life lest, conned a resistance of 20Ω/V to 1000Ω/V or more in series to each capacitor. (For detail see the specification) in additional, capacitors must be discharged with resistor before handling. Because the capacitor hasn't discharge resistor inside, so there is residual but maybe deathful electric energy contained.

6-4、电容器充放电

由于电容器充放电电流取决于电容量和电压上升速率的乘积，即使是低电压充放电，也可能产生大的瞬间充放电电流，这可能会导致电容器性能的损害，比如说短路或开络。当进行充放电时，请串联一个 20Ω/V∽1000Ω/V 或更高的即流电阻，将充放电电流限制在规定的范围内。

当多个薄膜电容器并联进行耐电压测试或寿命测试时，请为每个电容器串联一个 20Ω/V∽ 1000Ω/V 或更高的限流电阻，详见电容器标准。另外，在用手操作电容器之前必须对电容器进行充分放电，否则电容器内部残存的能量可能会对操作人员产生致命的伤害。

6-5. Buzzing noise

Any buzzing noise produced by capacitor is caused by the vibration of the film due to the coulomb force that is generated between the electrodes with opposite poles. If the wave-form with a high distortion rate or frequency is applied across the capacitor, the buzzing noise will become louder. But the buzzing noise is of no damage to capacitor.

6-6. Surface over temperature △Θ case

When continuing current flows through the capacitor, the temperature inside the capacitor will rise, induced by accumulated heat. If the temperature exceeds allowed hot-spot temperature, it might cause a short circuit or fire. The limits described in the catalogue are not exceeded and it's necessary to check the temperature or the capacitor surface when it works.

6-7. Flame retardation

Although flame retardation epoxy resin or plastic case is used in the coating or encapsulating of plastic film capacitor, continuous outer high temperature or firing will break the coating layer or plastic case of the capacitor, and may lead to meting and firing of the capacitor element.

6-5、因薄膜振动产生的嗡鸣声

电容器的嗡鸣声是由于电容器薄膜受到两电极间库仑力的作用ˆ产生的振动而发出的声音，施加的电压和频率波形失真越严里ˆ所产生的嗡鸣声越大۽但这种嗡鸣声对电容器不会产生任何破坏作用。

6-6、表面温升△Θ case

当电容器中通过持续电流时，热量累积会使电容器内部温度升高，当温度超出允许的热点温度时，可能会导致电容器短路甚至燃烧。因此，流经电容器的电流不允许超过产品目录所规定的最大数值，而且有必要监测电容器加载时的温升。

6-7、阻燃性

尽管在薄膜电容器外封装中使用了耐火性阻燃材料一阻燃聚氨酯或塑壳，但外部的持续高温或火焰仍可使电容器芯子变形而产生外封装破裂，导致电容器芯子熔化或燃烧。

针对电容器体积范围（mm^3） capacitor volume rage	体积≤250 volume	250<体积≤500 volume	500<体积≤1750 volume	1750<体积 volume	最大燃烧时间(s) maximum flame time
有效燃烧等级 class	施加火焰时间(s) flame time				
A	15	30	60	120	3
B	10	20	30	60	10
C	5	10	20	30	30

6-6. Humid ambient

If used for a long time in a humid ambient, the capacitor might absorb humidity and oxidise the electrodes causing breakage of the capacitor. If case of AC application, high humidity would increase the corona effect. This phenomenon causes a drop of capacitance and a increase of capacitor losses.

6-9. Storage conditions

1）Capacitors may not be stored in corrosive atmospheres, particularly not when chlorides, sulfides, acids, lye, salts, organic solvents or similar substances are present.

2）It shouldn't be located in particularly high temperature and high humidity, it must submit to the following conditions (unchanging primal package):

Temperature: ≤35℃

Humidity: ≤80%RH, no dew allowed on the capacitor.

Storage time: ≤24 months (from the date marked on the capacitor's body or the label glued to the package.

6-8、高湿环境

如果长时间使用在高湿环境下，电容器可能会吸收潮气、电极被氧化，导致电容器损坏。如果是在 AC 条件下使用.高湿环境将会加剧电晕的影响，从而引起电容量下降，损耗增加。

6-9、储存条件

1）电容器不能储存在腐蚀性的空气环境中.特别是存在氢化物、硫化物、酸、械、盐、有机溶剂或类似物质时。

2）产品不能暴露在高温和高湿状态，必须保存在以下环境中：(在不拆开原包装的基础上)

温度：不超过 35℃

湿度：不超过 80%RH 不允许有冷露

储存时间：不超过 24 个月（从产品包装或产品本体上的日期算起）

7. Typical failure modes and factors of film capacitors

7、薄膜电容器失效模式及原因分析

Failure mode 失效模式	Failure mechanism (internal phenomenon) 失效现象	Production factor 制造原因	Application factor 使用原因

Technical Notes